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Douglas-fir Habitat Types of Northern Arizona

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Abstract

Four Douglas-fir *(Pseudotsuga menziesii)* habitat types and two phases were identified from a reconnaissance survey of 46 Douglas-fir stands in northern Arizona. General descriptions of these habitat types are presented, and a key to their identification is provided.

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INTRODUCTION

Habitat type classification, originally developed for northern Idaho and eastern Washington by Daubenmire (1952), has been extended to many areas of the West (Pfister 1977, Pfister 1981, Steele et al. 1981). Such a classification provides a natural means for dividing diverse forest conditions into an hierarchical system that establishes a basis for communication, especially regarding responses of the ecosystem to management activities. Habitat types describe areas of land that are capable of supporting the same plant associations. Although such associations represent the potential climax vegetation, existing vegetation within a habitat type may be quite variable, reflecting different stages of successional development (Arno and Pfister 1977).

Layser and Schubert (1979) described coniferous and woodland series, the hierarchical level classified by the potential climax overstory. Within these series, limited descriptions of habitat types have been published for the spruce-fir (*Picea-Abies*)[2] and mixed conifer types (Moir and Ludwig 1979) and ponderosa pine (*Pinus ponderosa*) types (Hanks et al. 1983). Other studies are being conducted to describe the habitat types within all coniferous forest series of selected geographic units. The objectives of the study reported here were to determine existing habitat types in the Douglas-fir (*Pseudotsuga menziesii*) series of northern Arizona, and to be certain that all forest series were adequately sampled to provide continuity with the earlier studies. In addition to habitat type descriptions, this paper includes a key to identify habitat types in the field.

STUDY AREA

The study area was restricted to the Douglas-fir zone in northern Arizona, which lies almost entirely within the Colorado Plateau Province (Wilson 1962). Most Douglas-fir stands in northern Arizona are within the boundaries of the Coconino, Kaibab, and Apache-Sitgreaves National Forests (fig. 1). Distribution of sampled stands by National Forest and Ranger District is shown in table 1.

Sampled stands exhibited a wide variety of site characteristics, growing at elevations ranging from 6,580 to 9,600 feet (2,005 to 2,925 m), on slopes ranging from 5% to 72%, and on all aspects. Soils were equally variable, having been developed from such diverse parent materials as andesite, basalt, and limestone.

[2]*Nomenclature follows Lehr (1978) unless otherwise noted. A complete list of species encountered in this study can be found in Appendix B.*

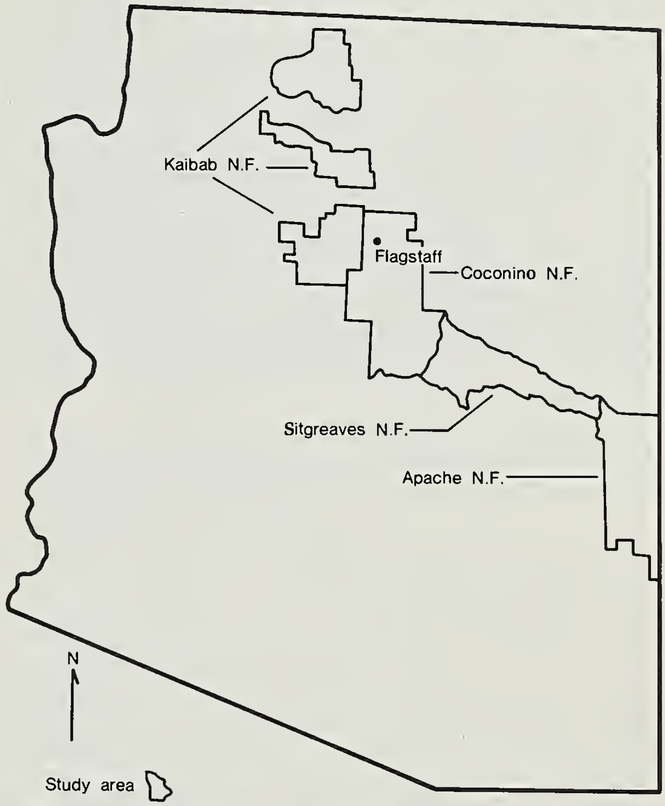

Figure 1.—National Forest boundaries encompassing study area within northern Arizona.

Although data were not collected, climatological conditions associated with the stands also were probably quite diverse. Extrapolating from climatological studies of ponderosa pine types in central Arizona by Beschta (1976), it appears that the Douglas-fir zone receives more than 25 inches of mean annual precipitation and has an average snowfall depth greater than 75 inches.

Table 1.—Douglas-fir plot locations by National Forest and Ranger District

National Forest	Ranger District	Number of plots
Kaibab	North Kaibab	10
	Chalender	5
	Williams	1
Coconino	Elden	9
	Blue Ridge	3
	Fort Valley	1
Apache-Sitgreaves	Clifton	5
	Alpine	9
	Springerville	3

METHODS

Field Sampling

Field sampling followed the procedures described by Pfister and Arno (1980). Sample stands were selected using the following criteria: (1) Douglas-fir dominated the stand or was a codominant species; (2) if it was a codominant, it exhibited as many or more stems in younger size classes as that shown by other codominants; (3) the stand was relatively undisturbed and mature, containing relatively old individual trees; and (4) the stand obviously was not an ecotone between other habitat types. Although Douglas-fir forests cover a relatively small geographical area, they are still subject to disturbances common to other forest types, especially those from timber harvesting and grazing by domestic livestock. Such areas were excluded from sampling in order to more accurately describe undisturbed conditions. Logged areas were quite obvious, whereas determining excessive grazing use required more careful observation regarding the presence of indicator species and recent soil disturbances.

An attempt was made to sample the entire range of site conditions that might support a Douglas-fir potential climax community, utilizing input from USDA Forest Service personnel to locate possible sample stands. Stands where *Abies concolor* was the dominant timber species, either in the overstory canopy or in regeneration size classes, were not sampled.

Once a stand was selected, a 375-m² circular plot was established in what appeared to be a relatively homogeneous and representative portion of the stand. Each plot center was permanently marked with an aluminum stake to facilitate relocation. Plot locations were identified on 1/2-inch scale National Forest maps and on topographic quadrangles, and were described by physiographic province, National Forest, Ranger District, locality, and legal description.[3]

Plots were described by elevation, slope, aspect, landform, parent material, and surface soil characteristics. Also included was the percentage of the plot surface covered by rocks, mosses, vascular plants, and litter. Notes were made regarding evidence of past fire, logging or grazing activity, and adjacent plant communities.

Vegetation in the plots was described in detail. The number of trees 2 inches or larger in diameter at breast height (d.b.h.) was recorded by species in 2-inch diameter size classes. Number of stems in two reproductive classes—(1) seedlings between 0.5 and 4.5 feet in height, and (2) saplings taller than 4.5 feet but less than 2 inches d.b.h.—was also recorded by species. At each plot center, basal area for the stand was sampled using a 10-factor prism to clarify stand structure; data were not used for estimating productivity.

Shrubs, forbs, and graminoids were recorded by species and percentage of plot area covered. The reliability of cover estimates was checked in the first plot, and in every tenth plot thereafter, by recording percentage cover in 50 systematically placed, 20- × 50-cm quadrats within a 15- × 25-m, rectangular plot, overlying the original circular plot (Daubenmire and Daubenmire 1968). The percentage cover of an individual species within each quadrat was recorded by coverage class as outlined in Daubenmire (1968). Any species found in the stand, but not in a plot, was simply noted as present in the stand.

[3]*Data on file at the Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Flagstaff, Ariz.*

Data Analysis

As with field sampling, data analysis followed guidelines suggested by Pfister and Arno (1980). After all data were computer coded, subjective groupings of stands were made on the basis of similarity between vegetation composition and structure of the stands. Stands were then organized into a synthesis table consisting of species (rows) and stands (columns). By rearranging the order of stands into different groupings, the aggregation of stands could be compared, and if necessary, constantly refined by further rearrangement.

Once groupings appeared satisfactory, as judged by greater similarity of vegetation within than between groups, a principal component analysis (PCA) of the data was made. PCA ordinates stands on abstract axes, positioning them, relative to one another, on the basis of similarity of percentage cover of individual species (Nichols 1977). Then, by comparing distribution of stands from the PCA to the subjective groupings, the validity of the latter could be verified more easily. If a stand appeared to be misgrouped as a result of the comparison, it was placed into a more appropriate group, or a new group was defined. Any changes made because of ordination were then incorporated into a new synthesis table. Throughout these procedures, continual reference was made to detailed field forms containing information on abiotic factors and observations to better explain vegetational relationships defined during analysis.

This procedure—continued refinement of groupings through synthesis table construction followed by PCA analysis—was repeated until individual groups were judged to represent a habitat type (h.t.). Furthermore, site characteristics, such as abiotic factors and histories of plot disturbances, were compared to maintain greater consistency within groups. According to Pfister and Arno (1980), such an iterative approach of successive approximations is central to the development of a habitat type classification.

Once habitat types were defined, vegetation and environmental data were synthesized to provide descriptions of the habitat types and to determine important indicator species. Finally, a key was developed to help the user determine the habitat type of sites in the Douglas-fir series within the study area.

RESULTS AND DISCUSSION

The four Douglas-fir habitat types of northern Arizona defined in this study are listed in table 2. In the following section, these habitat types are described with

Table 2.—Douglas-fir habitat types of northern Arizona, including name, abbreviation of the type and number of plots sampled in the type

Habitat type	Abbreviation	No. plots
Pseudotsuga menziesii/ Muhlenbergia virescens	PSME/MUVI h.t.	9
Pseudotsuga menziesii/Festuca arizonica	PSME/FEAR h.t.	6
Pseudotsuga menziesii/Quercus gambelii	PSME/QUGA h.t.	10
Muhlenbergia virescens phase	MUVI phase	1
Pseudotsuga menziesii/Sparse undergrowth	PSME/SPARSE h.t.	11
North Kaibab phase	N.K. phase	9

respect to diagnostic vegetation, topography, and ecotones and adjacent habitats. A brief discussion of each habitat type also is included.

A key to identify forest series and Douglas-fir stands by habitat types is presented in Appendix A. A plant list of all species found in sampled stands is shown in Appendix B. The average density and constancy (percentage occurrence within plots sampled) of trees and average cover and constancy of shrubs, graminoids, and forbs are listed in Appendix C.

Although the habitat type key is easy to apply, it has limitations that users must consider. First, the key is designed to be used in relatively undisturbed stands, because successional patterns leading to most habitat types are not yet well understood. Second, the key is intended for stands where Douglas-fir apparently will be the dominant tree species of the climax association, reproducing well enough to ensure its continued position in the stand. In situations where there is some doubt that Douglas-fir will be a prominant component of the climax community, users should consult references relating to habitat types of adjacent forest series, particularly Moir and Ludwig (1979) for spruce-fir and mixed conifer forests and Hanks et al. (1983) for the ponderosa pine series. Third, after the key has led to selection of a particular habitat type, compare the observed stand characteristics with the general description of the habitat type to see how well the stand fits the description. If the stand does not fit the description very well, try the key again, because it is only an identification aid and should always be used in conjunction with habitat type descriptions.

Pseudotsuga Menziesii/Muhlenberia Virescens H.T. (PSME/MUVI; Douglas-fir/Screwleaf Muhly)

Diagnostic Vegetation

Pseudotsuga menziesii, the dominant timber species of this habitat type (fig. 2), regenerates well at all stand ages. *Abies concolor* is only accidental or rare, being represented best in the younger age classes. *Pinus ponderosa*, although low in density, is represented equally throughout the various size classes; its abun-

Figure 2.—*Pseudotsuga menziesii/Muhlenbergia virescens* habitat type. Plot 037, Horse Springs, Apache National Forest (8,280 feet or 2,525 m). This stand has good representation of *Pseudotsuga menziesii* in all size classes, with grass cover of *Muhlenbergia virescens* and low shrub cover.

dance, however, is reduced in stands approaching climax conditions. *Pinus strobiformis* also is present in small amounts, but is a prominent component of old stands. However, it is neither as abundant nor as dominant as *Pseudotsuga menziesii*.

Characteristically, the PSME/MUVI h.t. lacks a well-defined shrub layer. *Quercus gambelii* occurs only in trace amounts when found at all; it usually is absent. *Berberis repens*, *Pachystima myrsinites*, and *Symphoricarpos oreophilus* are all noticeably absent from samples of this type.

In marked contrast to shrubs, the grass component of this habitat type is well developed. Coverage of *Muhlenbergia virescens*, the diagnostic indicator species of this habitat type, varies from trace amounts to as much as 15%. While *Festuca arizonica* may be present in this type, it is minor with lower coverage values. Although *Koeleria pyramidata* (*K. cristata*)[4] can be found on most sites throughout the type, it is not a good indicator, because it often is found in other types as well. *Bromus richardsonii*, *Carex rossii*, *Sitanion hystrix*, and *Poa fendleriana* are all common elements of this habitat type.

Within the forb component, *Dugaldia hoopesii* (*Helenium hoopesii*) is a consistent species, and although never covering more than 1% of a plot, it usually can be found. *Lithospermum multiflorum*, *Geranium richardsonii*, and *Fragaria ovalis* also are common elements. Ubiquitous species which occur throughout this type include *Thalictrum fendleri* and *Pseudocymopterus montanus*.

[4]*Scientific nomenclature follows Lehr (1978), which is most current. However, that of Kearney and Peebles (1960) is cited in parentheses where different from Lehr, because it is more commonly used in Arizona.*

Topography

The PSME/MUVI h.t. was sampled between 7,800 and 8,700 feet (2,375 to 2,650 m) elevation. It is found primarily on northwest- to west-facing slopes, but occasionally occurs on south aspects as well. Generally, the PSME/MUVI h.t. is found on ridge sideslopes or on upper slopes of large canyons. The type has a well developed litter layer and low (less than 10%) rock coverage on the soil surface. This habitat type was sampled on basaltic parent material.

Ecotones and Adjacent Habitats

The PSME/MUVI h.t. is commonly found between wetter *Abies concolor* habitat types and drier *Pinus ponderosa* habitat types. It often can be found on drier sides of ridges, with *Abies concolor* on wetter sides and ridge tops. Quite often, the transition into the PSME/MUVI h.t. is abrupt, signalling an equally abrupt environmental change. Typical *Pinus ponderosa* habitat types found at elevations below the PSME/MUVI h.t. are the PIPO/MUVI h.t. or the PIPO/MUVI-FEAR h.t. (Hanks et al. 1983).

Discussion

The PSME/MUVI h.t., a widespread and abundant type in the Douglas-fir series of the study area, is found in the Apache-Sitgreaves National Forest in the White Mountains. Although no stands were observed generally west of the White Mountains, the habitat type may occur near the western part of the Mogollon Rim, where site characteristics and environmental situations similar to those in the White Mountains can be found.

The area covered by individual stands of the PSME/MUVI h.t. is relatively small. However, extensive stands can be found in the Campbell River and Bear Creek areas, presumably because of the greater areal expanse of ridge sideslopes with environmental conditions favorable to support the PSME/MUVI h.t.

Moir and Ludwig (1979) recognize a *Pseudotsuga menziesii-Pinus strobiformis/Muhlenbergia virescens* habitat type. Evidence from this study supports their general description, but differs in that *Pinus strobiformis* is not recognized as a dominant climax species; Moir and Ludwig support this conclusion.[5] Moir and Ludwig (1979) also indicate that this habitat type is located on south and west aspects, whereas in this study, many plots were found on northwest and east aspects.

Because of the inherent susceptibility of young Douglas-fir to surface fires, the PSME/MUVI h.t. probably is greatly influenced by fire. Frequent fires of low intensity would likely favor *Muhlenbergia virescens* and would reduce the number of trees growing into the overstory. Whether the overstory composition would change from *Pseudotsuga menziesii* to *Pinus ponderosa*, however, is questionable. Although some stands in this habitat type contained old, fire-scarred *Pinus ponderosa*, others showed little or no evidence of fire; but *P. ponderosa* was still present.

[5]*Personal communication with William H. Moir, USDA Forest Service, Southwestern Region, Albuquerque, N. Mex., 1982.*

Pseudotsuga Menziesii/Festuca Arizonica H.T. (PSME/FEAR; Douglas-fir/Arizona Fescue)

Diagnostic Vegetation

Pseudotsuga menziesii is the dominant climax tree species in the PSME/FEAR h.t. (fig. 3), and regeneration is often moderate to heavy under an old-growth canopy. *Abies concolor* is absent from this habitat type, while *Pinus ponderosa* maintains itself under the *Pseudotsuga menziesii* canopy, but always in a subclimax or successional status. *Pinus strobiformis* is a minor climax species, but never attains the status of *Pseudotsuga menziesii*. At higher elevations within this habitat type, *Pinus ponderosa* may be absent.

There is essentially no representation of a shrub layer in this habitat type, except for *Berberis repens*, with an average cover of about 4% for stands sampled in this study.

The grass component is well developed, with as much as 10% to 15% of a given plot covered by grass. *Festuca arizonica* occurs in all stands, and is a diagnostic feature for identifying this habitat type. *Muhlenbergia montana* is nearly as constant and abundant as *Festuca arizonica*, but is much more ubiquitous, occurring throughout a variety of habitat types. *Poa fendleriana* also is constant in this habitat type, but is so ubiquitous as to be of little use as an indicator species. Other common graminoid species include *Bromus richardsonii*, *Carex rossii*, and *Sitanion hystrix*.

Species constituting the forb layer of the PSME/FEAR h.t. show low constancy values. Forbs that are common, but not restricted to this habitat type, include *Antennaria parvifolia*, *Lithospermum multiflorum*, *Penstemon barbatus*, and *Pseudocymopterus montanus*. Percent coverage of *Valeriana capitata* (*V. acutiloba*) is occasionally high, but the species is often absent.

Topography

The elevational range of the PSME/FEAR h.t. is wide. It can be found as low as 6,800 feet (2,075 m) and as high as 9,500 feet (2,895 m), but most commonly occurs near 8,500 feet (2,590 m). The PSME/FEAR h.t. can be found on ridge sideslopes and occasionally in canyons on upper slopes, usually on east or northeast exposures. A relatively high percentage of mineral soil and rock is exposed in this type. Fifteen percent of a plot may be bare ground and rock, which is consistently higher than in other *Pseudotsuga menziesii* types. Andesite and basalt were common parent materials found at sites of this habitat type.

Ecotones and Adjacent Habitats

The PSME/FEAR h.t. often occurs where, because of topography, the transitional zone from *Pinus ponderosa*

to *Abies concolor* habitat types is rather gradual. The PSME/FEAR h.t. commonly is found on upland sites, away from the Mogollon Rim. A typical habitat type in the adjacent *Pinus ponderosa* series is *Pinus ponderosa/Festuca arizonica*, while the *Abies concolor/ Festuca arizonica* habitat type is representative of the adjacent *Abies concolor* series.

Discussion

The PSME/FEAR h.t. is found throughout the Coconino and Kaibab National Forests, in the vicinity of the San Francisco Peaks, except the area east of the Blue Ridge Ranger District of the Coconino. However, it may well occur on the Chevelon Ranger District of the Apache-Sitgreaves National Forest, because the area exhibits environmental conditions that appear similar to other locations where the type is found.

On the Coconino National Forest, this habitat type was found to occupy more area than other habitat types in the *Pseudotsuga menziesii* series. As with the PSME/MUVI h.t., the PSME/FEAR h.t. is greatly influenced by fire. With very frequent fires, *Festuca arizonica* would increase in abundance, while canopy densities would probably be reduced. Similar to the PSME/MUVI h.t., many plots had no old, fire-scarred *Pinus ponderosa* upon which to base past fire history. As a consequence, the question again arises as to whether *Pseudotsuga menziesii* would be dominant under a frequent fire regime.

Pseudotsuga Menziesii/Quercus Gambelii H.T. (PSME/QUGA; Douglas-fir/Gambel Oak)

Diagnostic Vegetation

Pseudotsuga menziesii is the climax dominant tree species in the PSME/QUGA h.t. (fig. 4). Even though the

Figure 3.—*Pseudotsuga menziesii/Festuca arizonica* habitat type. Plot 044, San Francisco peaks, Coconino National Forest (8,600 feet or 2,620 m). *Festuca arizonica* is the dominant grass species; shrub cover is low under a relatively open canopy.

Figure 4.—*Pseudotsuga menziesii/Quercus gambelii* habitat type. Plot 023, East Eagle Creek, Apache National Forest (7,520 feet or 2,290 m). The canopy on these sites is often open, with *Pinus ponderosa* present. *Quercus gambelii* is prominent and percent grass cover is low.

canopy in seral stands may be composed of other tree species, *Pseudotsuga menziesii* is the dominant class of regeneration. *Abies concolor* may be present in this habitat type as a minor timber species, but it does not attain dominant status. In instances where regeneration of *Abies concolor* is present, that of *Pseudotsuga menziesii* will still be found in far greater numbers. Although *Pinus strobiformis* and *Pinus ponderosa* can occur in all age classes, both are minor climax species in older stands. On sites dominated by old individuals of *Pseudotsuga menziesii*, *Pinus strobiformis* will have a greater density than *Pinus ponderosa*.

Gambel oak (*Quercus gambelii*) in the area covered by this habitat type classification was observed only in shrub form, in contrast to *Pinus ponderosa* habitat types developed by Hanks et al. (1983), in which Gambel oak reached tree size. As indicated by the habitat type name, the shrub layer is dominated by *Q. gambelii*, which can cover as much as 70% of a plot. Under conditions where canopy coverage by Gambel oak is high, the density of the mature timber overstory is greatly reduced, apparently because of competition from the Gambel oak undergrowth. Conifer regeneration in the understory, however, may still be high. *Berberis repens*, *Pachystima myrsinites*, *Robinia neomexicana*, and *Symphoricarpos oreophilus* are common.

Poa fendleriana is common, but *Bromus richardsonii* and *Carex rossii* contribute the largest percentage of grass or grasslike cover. The latter species, while most constant, are not diagnostic because of their ubiquity in other habitat types of the *Pseudotsuga menziesii* series. Small amounts of *Muhlenbergia virescens* also may occur, but overall, the graminoid component of the typic phase is not well developed.

There is little consistency in the forb component of this habitat type. *Dugaldia hoopesii* (*Helenium hoopesii*), *Lathyrus arizonicus*, *Pseudocymopterus montanus*, *Pter-*

idium aquilinum, and *Thalictrum fendleri* are all common elements of the undergrowth.

***Muhlenbergia virescens* phase.**—The MUVI phase of the PSME/QUGA h.t. differs from the typic phase in that the graminoid component is well developed. *Muhlenbergia virescens* will dominate the herbaceous undergrowth, with coverage values as high as 15%. *Bromus richardsonii*, *Carex rossii*, *Poa fendleriana*, and *Sitanion hystrix* are all common components, whereas *Festuca arizonica* and *Muhlenbergia montana* are absent.

Topography

The elevational range of the PSME/QUGA h.t. is variable. It is most prominent between 6,900 and 7,700 feet (2,105 and 2,345 m), but sites up to 9,000 feet (2,745 m) are not uncommon. Generally, the habitat type is found in canyons, at mid-slope. The ground surface of the PSME/QUGA h.t. can be quite rocky, reaching 20% coverage. The litter layer, however, is still well developed.

The MUVI phase can be found between 7,500 and 9,000 feet (2,285 and 2,745 m) on ridges situated at lower to middle slopes. It can occur on all aspects, with the south and southwest aspects most common. Soils can vary, often being thin and rocky.

Ecotones and Adjacent Habitats

The PSME/QUGA h.t. is often the lowest elevational representative of the *Pseudotsuga menziesii* series. It occurs on sites which are moist enough to support establishment of *P. menziesii*, generally protected drainages or canyons, where *Abies concolor* apparently becomes drought-stressed. Such differential moisture requirements result in abrupt transitions between adjoining habitat types, often related to microsite differences associated with sharp topographical changes.

Small stands of this habitat type can be found in steep drainages in the Mogollon Rim area. These stands are often adjacent to moist *Abies concolor* habitat types in drainage bottoms, probably the ABCO/QUGA h.t. Upslope from the PSME/QUGA h.t. in such drainages, the habitat type generally found is *Pinus ponderosa/Quercus gambelii*.

When the habitat type occurs on well-drained upland sites, generally as the MUVI phase, it is found between the drier *Pinus ponderosa/Muhlenbergia virescens* habitat type (Hanks et al. 1983) at lower elevations, and the *Abies concolor/Quercus gambelii* habitat type, *Muhlenbergia virescens* phase, at higher cooler sites. The MUVI phase of the PSME/QUGA h.t. bridges grass-dominated *Pinus ponderosa* habitat types and shrub-dominated *Abies concolor* habitat types.

Discussion

The PSME/QUGA h.t. is common on the Apache-Sitgreaves, Coconino, and Kaibab National Forests. It is located most frequently along the Mogollon Rim, in canyons dissecting the Rim. The habitat type can also be found along the eastern rim of the North Kaibab Plateau as it decends into the Colorado River Drainage.

Locally, the PSME/QUGA h.t. is very limited—so narrow in some areas that it can be considered only as an ecotone between the lower (warmer) pine forests and the higher (cooler) mixed conifer forests. In other areas, it may be lacking entirely.

Although only one plot representing the MUVI phase was sampled in this study, comparison with ongoing studies on the Gila National Forest,[6] where the MUVI phase of the PSME/QUGA h.t. is well documented, suggests that the sample plot was properly classified. It is believed that the phase is common on the Alpine and Clifton Ranger Districts of the Apache-Sitgreaves National Forest.

Pseudotsuga Menziesii/Sparse Undergrowth H.T. (PSME/SPARSE; Douglas-fir/Sparse Undergrowth)

Diagnostic Vegetation

Pseudotsuga menziesii is the dominant climax tree species in this habitat type (fig. 5), and its regeneration is sometimes quite heavy. *Abies concolor* often can be found on these sites as a minor component. Sites with greater than accidental *Abies concolor* representation, particularly in the regeneration classes, are ecotonal to *Abies concolor* habitat types. The relative abundance of *Pinus strobiformis* and *P. ponderosa* is a function of moisture; on wetter sites, *P. strobiformis* will be more abundant, while *P. ponderosa* will be more common on drier sites. Both pines are consistently found, but play a very minor part in the climax overstory.

The most diagnostic feature of the habitat type is the lack of a substantial shrub, grass, and forb undergrowth, which is generally less than 10% of the total plot coverage. Other habitat types of the *Pseudotsuga menziesii* series have undergrowth coverages greater than 10% with at least one diagnostic species exceeding 1%. An opening in the canopy will result in an increase in regeneration of *P. menziesii*, while undergrowth species remain sparse.

Berberis repens is the only shrub species which frequently showed more than 1% coverage in the PSME/SPARSE h.t. It is not diagnostic, however, because constancy was low and distribution was widespread throughout the *Pseudotsuga menziesii* series.

On the Coconino and southern part of the Kaibab National Forests, *Festuca arizonica* often can be found in the habitat type, but never with greater than 1% coverage. *Bromus richardsonii* and *Poa fendleriana* also are common grasses of this habitat type. There is very little consistency among the forbs of this habitat type.

North Kaibab (N.K.) phase.—The North Kaibab phase (fig. 6) was segregated from the general PSME/SPARSE h.t., because it displayed some features on the North

[6] *Personal communication with E. Lee Fitzhugh, Wildlife Extension, University of California, Davis, 1982.*

Kaibab Plateau that were distinct from the southern counterpart of the habitat type. Primarily, the presence of *Clematis ligusticifolia* and *Valeriana capitata* (*V. acutiloba*) was common in the North Kaibab phase.

Pinus strobiformis was notably absent from this phase. *Berberis repens* is fairly constant, with coverage values greater than 1%, and *Pachystima myrsinites*, a small shrub component of this phase, is common. *Clematis ligusticifolia* and *Valeriana capitata* (*V. acutiloba*) are common species in the North Kaibab phase, although they rarely have coverage values greater than 1%. These two species are absent from the typic type of the Coconino and southern Kaibab National Forests.

Topography

The PSME/SPARSE h.t. ranges from 7,000 to 8,500 feet (2,135 to 2,590 m). In the Coconino and southern portion of the Kaibab National Forests, it can be found on ridges near mid-slope. On the Kaibab Plateau, it is found in canyons on lower slopes. Aspects generally range from east to northeast to north to northwest, but the North Kaibab phase is found strictly on north to northeast, and occasionally, northwest slopes.

Ecotones and Adjacent Habitats

In the Coconino and southern Kaibab National Forests, the PSME/SPARSE h.t. is transitional between the *Pinus ponderosa* grass and the *Abies concolor* shrub habitat types. Its presence may signify an environmental change that favors grass undergrowth rather than a closed canopy of shrubs. Changes from the lower *Pinus ponderosa* grass type to this PSME/SPARSE h.t. are usually abrupt; the canopy closes in, while the undergrowth vegetation practically disappears. The near absence of undergrowth vegetation cannot be attributed to any disturbance observed during the study.

Figure 5.—*Pseudotsuga menziesii*/Sparse undergrowth habitat type. Plot 001, Kendrick Peak, Kaibab National Forest (8,850 feet or 2,695 m). Canopy cover can be dense, with no representation of the shrub component, and low shrub diversity.

Figure 6.—*Pseudotsuga menziesii*/Sparse undergrowth habitat type, North Kaibab phase. Plot 007, Big Springs, Kaibab National Forest (7,500 feet or 2,285 m). Stands of this habitat type have a dense canopy, very little shrub representation and low forb cover. *Pinus strobiformis* is absent from these stands. This habitat type occurs only on the North Kaibab Plateau.

On the North Kaibab Plateau, the PSME/SPARSE h.t. is typically found in canyons. Transitions from other types to the PSME/SPARSE h.t. are rather abrupt, except for the more gradual mergence with adjacent *Abies concolor* types. In some instances, transitional changes are correlated with gradual changes in aspect.

Discussion

The PSME/SPARSE h.t. is, perhaps, the most difficult of *Pseudotsuga menziesii* habitats to identify. It exists as a distinct habitat type based on the lack of a diagnostic undergrowth, and has little affinity with other types. Two phases are recognized: the typic phase occurs in the Coconino and southern Kaibab National Forests, and the North Kaibab phase is found on the North Kaibab Plateau, as indicated by its name. The phases are quite distinct from each other regarding key species and locality, but share the lack of an abundant shrub, grass, and forb undergrowth.

The PSME/SPARSE h.t. includes plots found on the north side of the San Francisco Peaks and on the south side of Kendrick Peak. These plots are found on stony soils originating from either basalt or andesite, and are noteworthy because of the presence of *Pseudotsuga menziesii* at high elevations—8,500 to 8,900 feet (2,590 to 2,715 m). *Abies concolor*, while expected in this habitat type following observation of other sites with similar aspects and elevations, is noticeably absent, perhaps as a result of the well-drained nature of the soils, creating drier site conditions. The PSME/SPARSE h.t. may denote a warmer site that is similar to Moir and Ludwig's (1979) *Abies concolor-Pseudotsuga menziesii* (SPARSE) habitat type, but the relationship is not clear.

CONCLUSIONS

These descriptions may have to be modified somewhat as more stands are encountered and knowledge of each habitat type increases. However, each of the habitat types described in this paper are believed to be distinct, recognizable units in the environment.

The study denotes only the first stage in classification—the identification of habitat types. For such a classification to be most useful, additional information is needed on successional relationships within habitat types and on the response of habitat types to various types of treatment. This information can best be gained through the cooperative efforts of forest managers and forest researchers.

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APPENDIXES

Appendix A. Keys to the Series Level and Habitat Types for *Pseudotsuga menziesii* of Northern *Arizona*[1]

Key to Series

1. *Abies concolor* present, not accidental or seral	*Abies concolor* series (Moir and Ludwig 1979)
1. *Abies concolor* absent, or accidental	2
2. *Pseudotsuga menziesii* dominant, *Pinus ponderosa* codominant or seral	*Pseudotsuga menziesii* series (see habitat type key)
2. *Pseudotsuga menziesii* absent or accidental, *Pinus ponderosa* dominant, clearly not seral	*Pinus ponderosa* series (Hanks et al. 1983)

Key to Habitat Types

1. *Quercus gambelii* well represented (greater than 5% cover)	2
1. *Quercus gambelii* not well represented (less than 5% cover)	3
2. *Muhlenbergia virescens* common (greater than 1% cover)	PSME/QUGA MUVI PHASE
2. *Muhlenbergia virescens* scarce (less than 1% cover)	PSME/QUGA TYPIC PHASE
3. *Muhlenbergia virescens* present; *Festuca arizonica* absent or minor	PSME/MUVI
3. *Muhlenbergia virescens* absent or minor	4
4. *Festuca arizonica* common (greater than 1% cover)	PSME/FEAR
4. *Festuca arizonica* scarce (not over 1% cover); undergrowth never greater than 10% cover	5
5. Undergrowth sparse (less than 10% cover); Coconino and southern Kaibab National Forests	PSME/SPARSE TYPIC PHASE
5. Undergrowth sparse (less than 10% cover), *Clematis ligusticifolia* and *Valeriana capitata* common; North Kaibab Plateau	PSME/SPARSE N.K. PHASE

[1]*Percent canopy coverage values used in this key were derived from field data which were collected from 375-m² circular plots.*

Appendix B. Plant List from Sampled *Pseudotsuga menziesii* Stands in Northern Arizona

I. Trees

Abies concolor	ABCO[1]
Abies lasiocarpa	ABLA
Juniperus scopulorum	JUSC
Picea engelmannii	PIEN
Pinus edulis	PIED
Pinus ponderosa	PIPO
Pinus strobiformis	PIST
Populus tremuloides	POTR
Pseudotsuga menziesii	PSME

II. Shrubs

Amelanchier utahensis	AMUT
Berberis repens	BERE
Brickellia californica	BRCA
Ceanothus fendleri	CEFE
Holodiscus dumosus	HODU
Juniperus communis	JUCO
Lonicera spp.	LONICE
Lonicera involucrata	LOIN
Pachystima myrsinites	PAMY
Prunus spp.	PRUNUS
Prunus virginiana	PRVI
Quercus gambelii	QUGA
Rhamnus californica	RHCA
Ribes spp.	RIBES
Ribes aureum	RIAU
Robinia neomexicana	RONE
Rosa arizonica	ROAR
Rubus strigosus	RUST
Sambucus glauca	SAGL
Symphoricarpos oreophilus	SYOR
Vaccinium oreophilum	VAOR

III. Graminoids

Bromus richardsonii	BRRI
Carex spp.	CAREX
Carex rossii	CARO
Cyperus spp.	CYPERU
Festuca arizonica	FEAR
Koeleria pyramidata (*Koeleria cristata*)	KOPY
Luzula parviflora	LUPA
Melica porteri	MEPO
Muhlenbergia spp.	MUHLEN
Muhlenbergia montana	MUMO
Muhlenbergia virescens	MUVI
Oryzopsis micrantha	ORMI
Poa fendleriana	POFE
Schizachyrium scoparium (*Andropogon scoparius*)	SCSC
Sitanion hystrix	SIHY

IV. Forbs

Achillea millefolium (*Achillea lanulosa*)	ACMI
Antennaria marginata	ANMA
Antennaria parvifolia	ANPA
Aquilegia spp.	AQUELE
Aquilegia chrysantha	AQCH
Aquilegia elegantula	AQEL
Arabis fendleri	ARFE
Arenaria spp.	ARENAR
Arenaria eastwoodiae	AREA
Artemisia carruthii	ARCA
Artemisia dracunculus (*A. dracunculoides*)	ARDR
Artemisia ludoviciana	ARLU
Aster foliaceus	ASFO
Astragalus spp.	ASTRAG
Astragalus rusbyi	ASRU
Castilleja integra	CAIN
Chaptalia alsophila	CHAL
Chimaphila umbellata	CHUM
Cirsium parryi	CIPA
Clematis ligusticifolia	CLLI
Corallorhiza striata	COST
Cryptantha jamesii	CRJA
Cystopteris fragilis	CYFR
Disporum trachycarpum	DITR
Dugaldia hoopesii (*Helenium hoopesii*)	DUHO
Erigeron spp.	ERIGER
Erigeron divergens	ERDI
Erigeron macranthus	ERMA
Erigeron platyphyllus	ERPL
Erigeron superbus	ERSU
Eriogonum jamesii	ERJA
Eriogonum racemosum	ERRA
Euphorbia lurida	EULU
Fragaria bracteata	FRBR
Fragaria ovalis	FROV
Galium spp.	GALIUM
Galium boreale	GABO
Galium mexicanum (*Galium asperrimum*)	GAME
Geranium caespitosum	GECA
Geranium richardsoni	GERI
Heuchera parviflora	HEPA
Heuchera rubescens	HERU
Hieracium fendleri	HIFE
Hymenoxys richardsonii	HYRI
Ipomoea spp.	IPOMOE
Ipomopsis aggregata (*Gilia aggregata*)	IPAG
Ipomopsis multiflora (*Gilia multiflora*)	IPMU
Lathyrus arizonicus	LAAR
Lithospermum multiflorum	LIMU
Lotus wrightii	LOWR
Lupinus argenteus	LUAR
Malaxis soulei	MASO

Appendix B.—(Continued)

Mirabilis oxybaphoides	MIOX	*Rhus radicans*	RHRA
Monotropa spp.	MONOTR	*Sedum* spp.	SEDUM
Monotropa latisquama	MOLA	*Senecio bigelovii*	SEBI
Mustard spp. (*Cruciferae* family)	MUSTAR	*Senecio eremophilus* (*Senecio macdougalii*)	SEER
Orchid spp. (*Orchidaceae* family)	ORCHID	*Senecio neomexicanus*	SENE
Osmorhiza chilensis	OSCH	*Silene laciniata*	SILA
Osmorhiza depauperata	OSDE	*Silene scouleri*	SISC
Oxalis alpina (*Oxalis metcalfei*)	OXAL	*Smilacina racemosa*	SMRA
Oxytropis lambertii	OXLA	*Smilacina stellata*	SMST
Penstemon spp.	PENSTE	*Solidago decumbens*	SODE
Penstemon barbatus	PEBA	*Solidago sparsiflora*	SOSP
Penstemon virgatus	PEVI	*Stellaria jamesiana*	STJA
Petrophytum caespitosum	PECA	*Swertia radiata*	SWRA
Phaseolus parvulus	PHPA	*Thalictrum fendleri*	THFE
Polemonium foliosissimum	POFO	*Thermopsis pinetorum*	THPI
Potentilla crinita	POCR	*Thlaspi* spp.	THLASP
Potentilla norvegica	PONO	*Valeriana capitata* (*V. acutiloba*)	VACA
Potentilla thurberi	POTH	*Vicia* spp.	VICIA
Pseudocymopterus montanus	PSMO	*Vicia americana*	VIAM
Pteridium aquilinum	PTAQ	*Vicia pulchella*	VIPU
Pterospora andromeda	PTAN	*Viola* spp.	VIOLA
Pyrola secunda	PYSE	*Viola canadensis*	VICA

[1]*Four letter acronyms were formed from the first two letters of the generic name and the first two letters of the specific name. In those cases where an individual was only identified to genus, a six-letter acronym was assigned using the first six letters of the generic name (or a five letter acronym was used if the generic name contained only five letters).*

Appendix C. Table of Average Cover and Constancy of Major Species by *Pseudotsuga menziesii* Habitat Types in Northern Arizona[1]

Species	PSME/QUGA		PSME/MUVI	PSME/FEAR	PSME/SPARSE	
	MUVI Phase (N = 1)	Typic Phase (N = 10)	(N = 9)	(N = 6)	Typic Phase (N = 11)	N.K. Phase (N = 9)
Trees						
Abies concolor < 4.5 ft	.	4.2/60	1.3/44	.	20.0/36	33.5/22
A. concolor > 4.5 ft and < 2 inch d.b.h.	.	2.5/20	1.5/22	2.0/17	2.5/18	10.0/11
A. concolor 2-4 inch d.b.h.	.	3.5/70	1.3/44	1.0/17	2.0/9	1.0/11
A. concolor 4-6 inch d.b.h.	.	4.0/50	1.0/11	2.0/17	3.0/9	.
A. concolor 6-8 inch d.b.h.	.	2.0/20	1.0/11	1.0/17	.	1.0/22
A. concolor 8-10 inch d.b.h.	.	1.5/30	.	.	1.0/9	.
A. concolor 10-12 inch d.b.h.	.	1.0/30	.	.	1.0/9	.
A. concolor 12-14 inch d.b.h.	.	.	.	.	.	.
A. concolor 16-18 inch d.b.h.	.	.	.	.	.	1.0/11
A. concolor 18-20 inch d.b.h.	.	.	.	.	.	.
A. concolor 20-22 inch d.b.h.	.	.	.	.	.	.
A. concolor > 22 inch d.b.h.	.	.	.	.	1.0/9	.
Pinus ponderosa < 4.5 ft	1.0/100	1.6/30	1.8/44	6.5/67	1.5/18	2.0/11
P. ponderosa > 4.5 ft and < 2 inch d.b.h.	1.0/100	2.0/30	2.0/44	6.0/17	5.3/36	1.0/11
P. ponderosa 2-4 inch d.b.h.	4.0/100	1.4/50	5.3/44	2.3/50	3.8/45	3.0/22
P. ponderosa 4-6 inch d.b.h.	6.0/100	2.0/50	3.3/67	1.8/67	2.0/54	2.3/44
P. ponderosa 6-8 inch d.b.h.	.	1.5/60	1.3/44	1.0/17	2.8/45	1.5/44
P. ponderosa 8-10 inch d.b.h.	.	1.5/40	1.4/56	1.5/33	2.5/54	1.2/55
P. ponderosa 10-12 inch d.b.h.	.	2.5/20	1.8/56	3.0/17	1.0/36	1.8/44
P. ponderosa 12-14 inch d.b.h.	.	1.0/10	1.0/33	1.5/33	1.0/18	1.0/33
P. ponderosa 14-16 inch d.b.h.	.	2.0/10	1.2/56	1.0/33	1.0/9	1.3/44
P. ponderosa 16-18 inch d.b.h.	.	2.0/10	1.0/22	1.5/33	1.0/36	1.5/22
P. ponderosa 18-20 inch d.b.h.	.	1.0/10	1.3/33	1.0/17	1.0/18	1.0/33
P. ponderosa 20-22 inch d.b.h.	.	1.0/20	1.0/22	1.0/17	1.0/9	.
P. ponderosa > 22 inch d.b.h.	.	1.0/10	1.0/22	1.0/17	1.0/9	1.5/44
Pinus strobiformis < 4.5 ft	1.0/100	2.2/50	1.2/67	5.2/83	4.8/73	.
P. strobiformis > 4.5 ft and < 2 inch d.b.h.	6.0/100	1.2/40	2.3/44	2.5/67	5.0/36	.
P. strobiformis 2-4 inch d.b.h.	.	1.4/50	2.2/56	4.2/83	3.8/45	.
P. strobiformis 4-6 inch d.b.h.	.	1.5/40	2.2/56	4.6/50	4.5/36	.
P. strobiformis 6-8 inch d.b.h.	.	1.2/40	2.0/33	1.6/50	2.3/36	.
P. strobiformis 8-10 inch d.b.h.	1.0/100	1.0/10	1.6/33	2.5/33	2.6/27	.
P. strobiformis 10-12 inch d.b.h.	.	1.0/10	1.3/44	1.5/33	1.7/27	.
P. strobiformis 12-14 inch d.b.h.	.	1.0/10	1.3/44	2.0/17	2.5/18	.
P. strobiformis 14-16 inch d.b.h.	1.0/100	.	.	1.0/17	1.0/9	.
P. strobiformis 16-18 inch d.b.h.	.	1.0/10	.	2.0/33	1.0/9	.
P. strobiformis 18-20 inch d.b.h.	.	.	.	.	1.0/27	.
P. strobiformis 20-22 inch d.b.h.	.	.	.	1.0/17	1.0/18	.
P. strobiformis > 22 inch d.b.h.	.	1.0/10	1.0/11	1.0/17	1.7/27	.
Pseudotsuga menziesii < 4.5 ft	5.0/100	24.8/90	11.2/100	10.0/100	31.2/91	12.8/77
P. menziesii > 4.5 ft and < 2 inch d.b.h.	4.0/100	11.6/80	13.7/100	5.0/83	21.8/73	13.8/55
P. menziesii 2-4 inch d.b.h.	3.0/100	9.8/100	12.0/89	6.2/100	16.5/91	8.9/77
P. menziesii 4-6 inch d.b.h.	4.0/100	4.0/70	2.9/89	9.0/50	4.8/91	6.1/77
P. menziesii 6-8 inch d.b.h.	.	3.6/60	5.4/56	4.5/33	4.1/91	3.4/77
P. menziesii 8-10 inch d.b.h.	.	2.4/50	3.0/78	2.6/50	4.0/82	1.4/51
P. menziesii 10-12 inch d.b.h.	.	3.0/40	2.6/67	2.0/33	2.0/82	3.4/55
P. menziesii 12-14 inch d.b.h.	1.0/100	1.0/30	1.6/56	1.5/33	1.5/54	2.0/44
P. menziesii 14-16 inch d.b.h.	2.0/100	1.0/30	1.0/44	1.5/33	1.0/45	1.5/44
P. menziesii 16-18 inch d.b.h.	.	2.0/20	2.5/22	2.0/17	1.0/9	1.5/22
P. menziesii 18-20 inch d.b.h.	.	1.0/20	1.0/33	1.0/17	1.8/45	1.0/33
P. menziesii 20-22 inch d.b.h.	.	1.0/50	1.0/33	1.0/50	1.3/36	2.0/11
P. menziesii > 22 inch d.b.h.	.	3.0/50	2.0/67	1.5/33	1.0/45	1.6/33
Shrubs						
Amelanchier utahensis	.	.	.	.	.	2.0/22
Berberis repens	.	1.3/20	.	3.8/83	1.8/73	2.1/89
Ceanothus fendleri	.	T/10	T/33	1.0/50	T/27	.
Holodiscus dumosus	.	.	.	2.0/17	2.0/9	.
Lonicera involucrata	.	1.0/10	.	.	.	1.0/22
Pachystima myrsinites	T/100	1.0/20	T/33	.	T/9	1.0/55
Quercus gambelii	40.0/100	22.0/100	T/22	T/17	1.0/9	1.7/55
Robinia neomexicana	6.0/100	1.5/50	2.0/11	3.0/17	1.0/9	T/55
Symphoricarpos oreophilus	2.0/100	4.5/30	.	1.0/17	T/54	4.1/55
Vaccinium oreophilum	.	.	.	.	.	.

Appendix C.—(Continued)

Graminoids						
Bromus richardsonii	T/100	1.0/80	T/78	1.0/83	T/82	T/22
Carex rossii	1.0/100	1.0/80	1.0/78	1.0/67	T/36	T/33
Festuca arizonica	.	T/10	2.0/22	3.8/100	T/91	.
Koeleria pyramidata	.	T/30	T/100	2.0/17	T/18	T/44
Muhlenbergia montana	.	.	.	4.4/83	1.0/45	.
Muhlenbergia virescens	18.0/100	1.0/40	4.5/00	5.0/17	.	.
Poa fendleriana	T/100	1.0/70	T/55	1.3/100	T/54	1.0/100
Sitanion hystrix	T/100	T/30	T/55	1.0/50	T/18	T/11
Forbs						
Antennaria marginata	.	T/10	T/11	.	.	.
Antennaria parvifolia	.	T/20	T/55	T/83	T/54	T/22
Cirsium parryi	T/100	T/40	.	T/33	T/9	T/11
Clematis ligusticifolia	.	.	.	.	.	1.0/100
Cystopteris fragilis	.	T/10	.	T/17	.	T/22
Erigeron superbus	.	.	.	.	.	.
Fragaria bracteata	.	.	T/11	.	T/9	.
Fragaria ovalis	.	T/20	T/67	T/33	T/27	T/11
Geranium richardsonii	.	T/10	T/67	T/33	T/9	T/55
Dugaldia hoopesii	T/100	T/60	1.0/89	T/33	T/18	.
Heuchera parviflora	T/100	T/10	.	.	.	T/22
Hieracium fendleri	T/100	T/30	.	T/33	.	.
Lathyrus arizonicus	T/100	1.0/70	T/55	.	T/27	T/11
Lithospermum multiflorum	T/100	T/20	T/67	T/83	T/27	T/22
Oxalis alpina	.	T/10	.	.	.	.
Penstemon barbatus	T/100	T/40	T/22	T/67	T/36	T/11
Pseudocymopterus montanus	T/100	T/60	T/55	T/50	T/27	T/11
Pteridium aquilinium	.	1.5/50	1.0/55	.	.	.
Senecio bigelovii	.	T/10	.	.	.	.
Senecio neomexicanus	.	T/10	T/22	T/50	T/9	.
Smilacina stellata	.	T/20	T/22	.	T/18	.
Smilacina racemosa	.	.	.	.	.	T/11
Stellaria jamesiana	.	.	T/11	.	.	T/11
Swertia radiata	.	.	.	.	T/18	.
Thalictrum fendleri	.	T/60	T/67	T/50	T/73	T/100
Thermopsis pinetorum	.	T/20	T/11	.	T/9	.
Valeriana capitata	.	T/20	.	3.5/33	T/18	1.0/100
Vicia americana	.	T/40	.	T/17	.	.

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[1]Occurrence of each species in each habitat type and phase is indicated by two values separated by a slash. The first indicates the mean density/plot for the tree species or the mean coverage/plot for the shrubs, grasses, and forbs. In all cases, however, the first value is the mean for only the plots in which the species was present. The value to the right of the slash is the percent constancy for each species in the habitat type and phase; it is the percentage of the total number of plots in the group in which the species was found. To indicate when a species had less than 1% cover, the letter T is used to the left of the slash. A dot indicates that the species was not found in a group. To show species occurrence, Moir and Ludwig (1979) use importance value, which is the product of mean density times constancy.

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Four Douglas-fir (*Pseudotsuga menziesii*) habitat types and two phases were identified from a reconnaissance survey of 46 Douglas-fir stands in northern Arizona. General descriptions of these habitat types are presented, and a key to their identification is provided.

Keywords: forest vegetation, plant associations, habitat types, forest ecology, *Pseudotsuga menziesii*, Arizona, Colorado Plateau.

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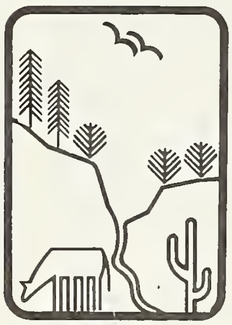
Rocky
Mountains



Southwest

Great
Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526